STAT626_MRI

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```r
library("tidyverse")
library("astsa")
```

Objective:

I am doing a freestyle EDA process to explore the data and get myself and everyone else more acquainted with it. I'll focus on the techniques we have covered so far.

Import the data

```r
# read in the data
mri <- read.csv("/Users/panders2/Documents/schools/tamu/stat_626/project/stat_626_proj/mri_dat_one.csv")
# update fields
names(mri) <- c("hour", "minute", "freq", "int_pressure", "atm_pressure", "tot_pressure", "tesla")
# take a look
str(mri)
```

```
## 'data.frame':    1603 obs. of  7 variables:
##  $ hour        : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ minute      : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ freq        : num  63800687 63800687 63800687 63800687 63800688 ...
##  $ int_pressure: num  2.95 2.95 2.96 2.97 2.97 ...
##  $ atm_pressure: num  14.7 14.7 14.7 14.7 14.7 ...
##  $ tot_pressure: num  17.6 17.6 17.6 17.6 17.7 ...
##  $ tesla       : num  1.5 1.5 1.5 1.5 1.5 ...
```

```r
head(mri)
```

```
##   hour minute     freq int_pressure atm_pressure tot_pressure   tesla
## 1    0      1 63800687        2.950       14.682       17.632 1.49851
## 2    0      2 63800687        2.953       14.682       17.635 1.49851
## 3    0      3 63800687        2.963       14.682       17.645 1.49851
## 4    0      4 63800687        2.967       14.682       17.649 1.49851
## 5    0      5 63800688        2.974       14.682       17.656 1.49851
## 6    0      6 63800688        2.979       14.682       17.661 1.49851
```

```r
summary(mri)
```

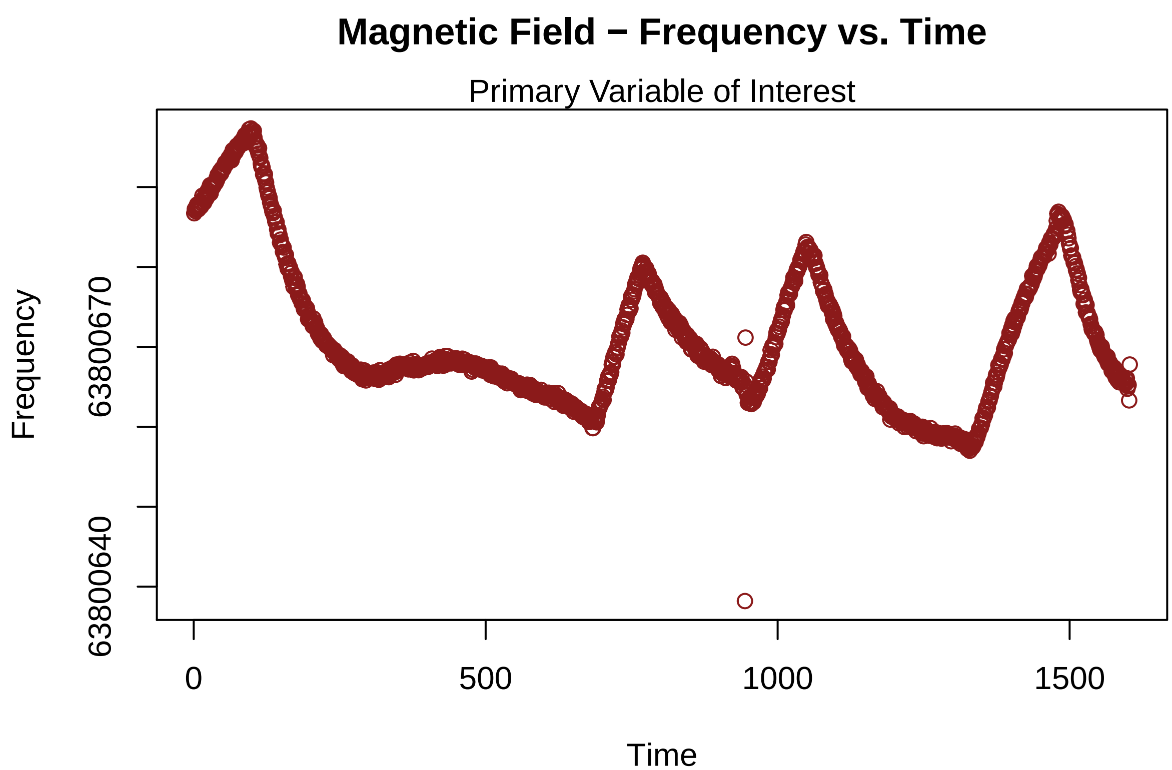
```
##       hour           minute           freq           int_pressure  
##  Min.   : 0.00   Min.   : 1.00   Min.   :63800638   Min.   :0.000  
##  1st Qu.: 6.00   1st Qu.:15.00   1st Qu.:63800665   1st Qu.:2.969  
##  Median :13.00   Median :30.00   Median :63800668   Median :3.006  
##  Mean   :12.86   Mean   :30.27   Mean   :63800671   Mean   :3.011  
##  3rd Qu.:20.00   3rd Qu.:45.00   3rd Qu.:63800676   3rd Qu.:3.055  
##  Max.   :26.00   Max.   :60.00   Max.   :63800697   Max.   :3.162  
##                                                                    
##   atm_pressure    tot_pressure       tesla      
##  Min.   :14.63   Min.   :17.60   Min.   :1.499  
##  1st Qu.:14.66   1st Qu.:17.63   1st Qu.:1.499  
```

```
##  Median :14.67   Median :17.67   Median :1.499
##  Mean   :14.66   Mean   :17.68   Mean   :1.499
##  3rd Qu.:14.68   3rd Qu.:17.72   3rd Qu.:1.499
##  Max.   :14.69   Max.   :17.80   Max.   :1.499
##                  NA's   :3
```

Remaking Eric's Plots

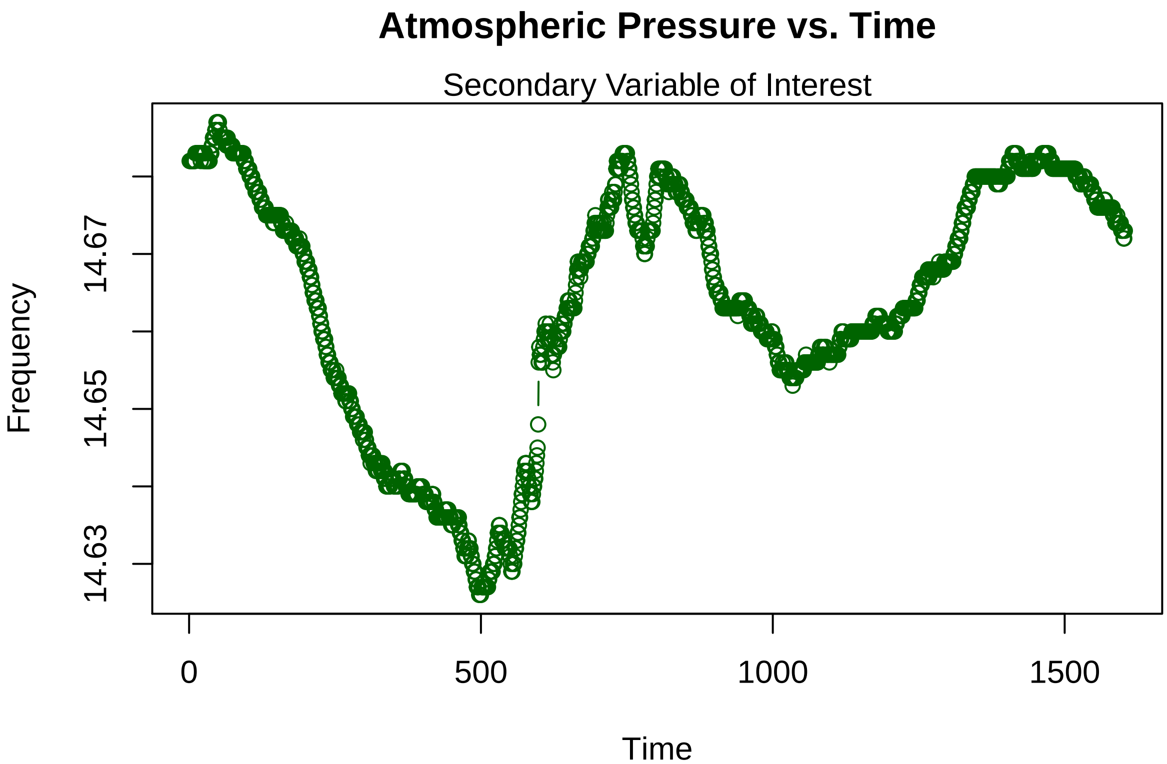
Primary Plot First

```r
plot(mri$freq, col="firebrick4"
     , main="Magnetic Field - Frequency vs. Time"
     , xlab="Time"
     , ylab="Frequency"
      )
mtext("Primary Variable of Interest")
```

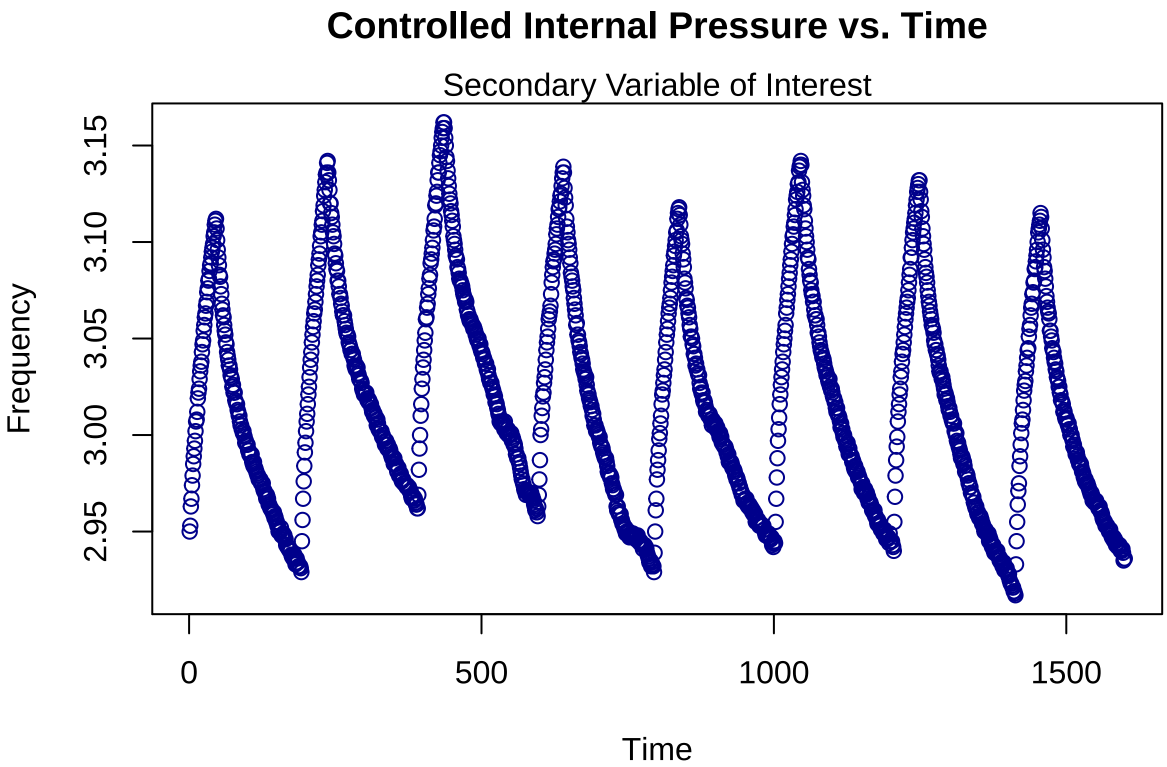


Covariate Plots Second

```r
plot(mri$atm_pressure, col="darkgreen", type="b"
     , main="Atmospheric Pressure vs. Time"
     , xlab="Time"
     , ylab="Frequency"
      )
mtext("Secondary Variable of Interest")
```

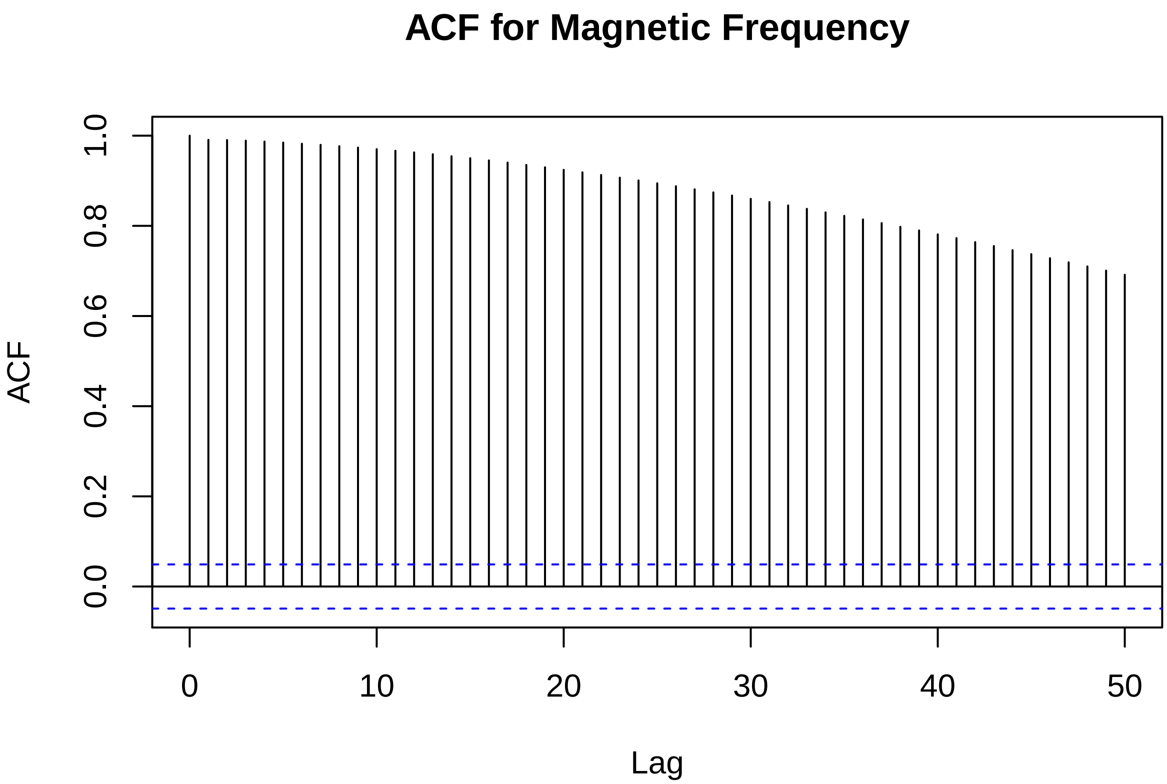



```
plot(mri$int_pressure[1:1600], col="darkblue", type="b"
     , main="Controlled Internal Pressure vs. Time"
     , xlab="Time"
     , ylab="Frequency"
      )
mtext("Secondary Variable of Interest")
```



Empirical Autocorrelation Functions

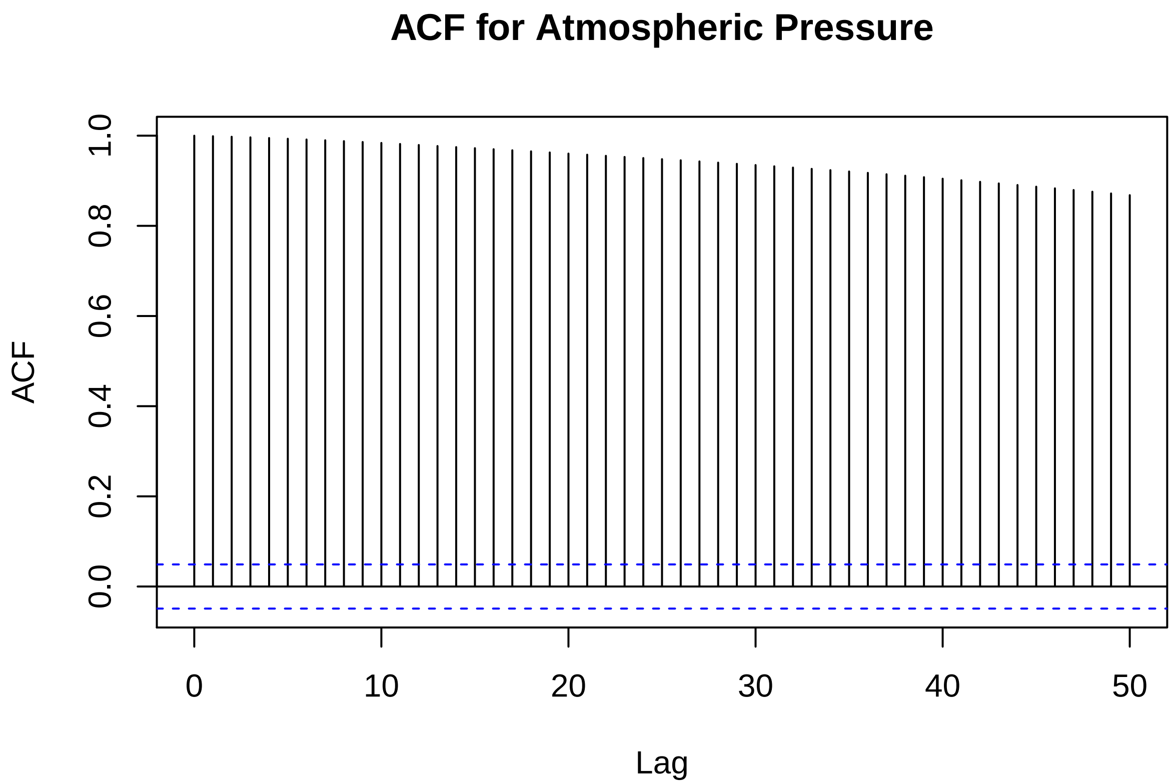
```
freq_acf <- acf(mri$freq, lag.max=50
                , main="ACF for Magnetic Frequency"
                )
```



So our main variable has a LOT of serial correlation and is far from stationary. This could be because of time iteration. Consider aggregation to every five minutes as Eric mentioned.

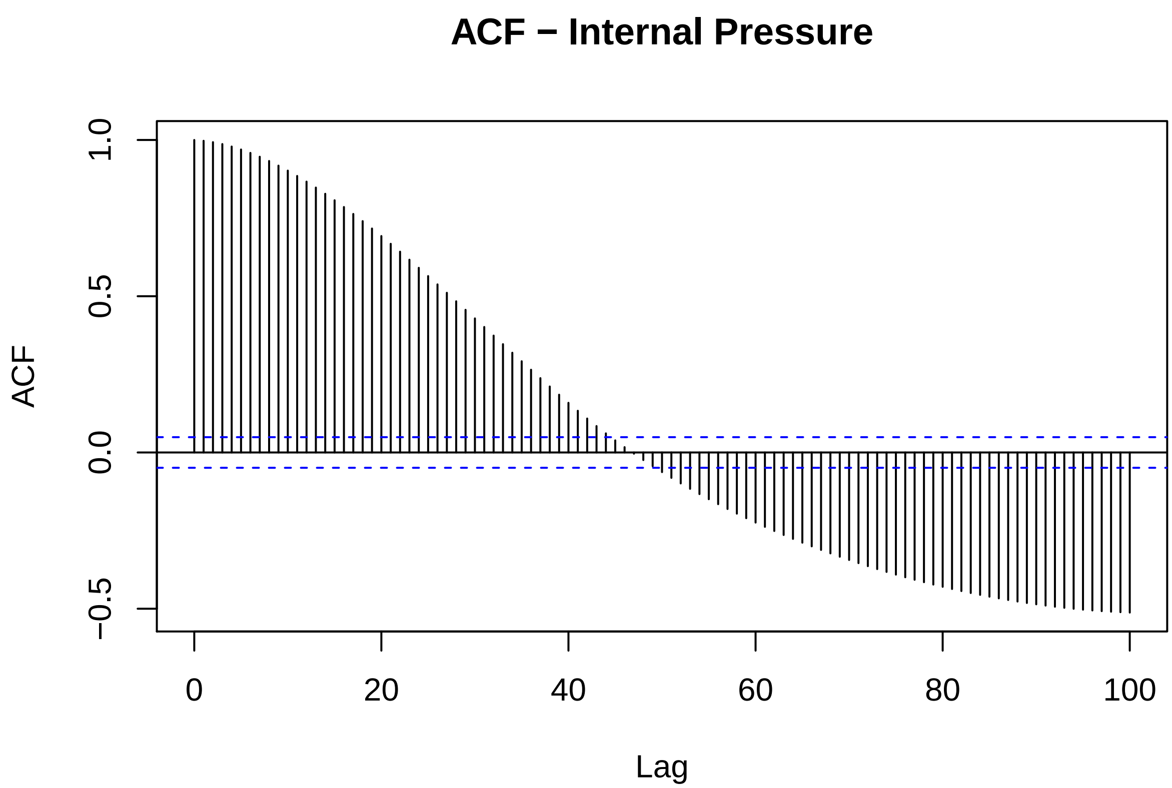
ACF for Secondary Variables

```
acf(mri$atm_pressure, lag.max=50
    , main="ACF for Atmospheric Pressure"
    )
```



Same story as above.

```
acf(mri$int_pressure[1:1600], lag.max=100
    , main="ACF - Internal Pressure"
  )
```

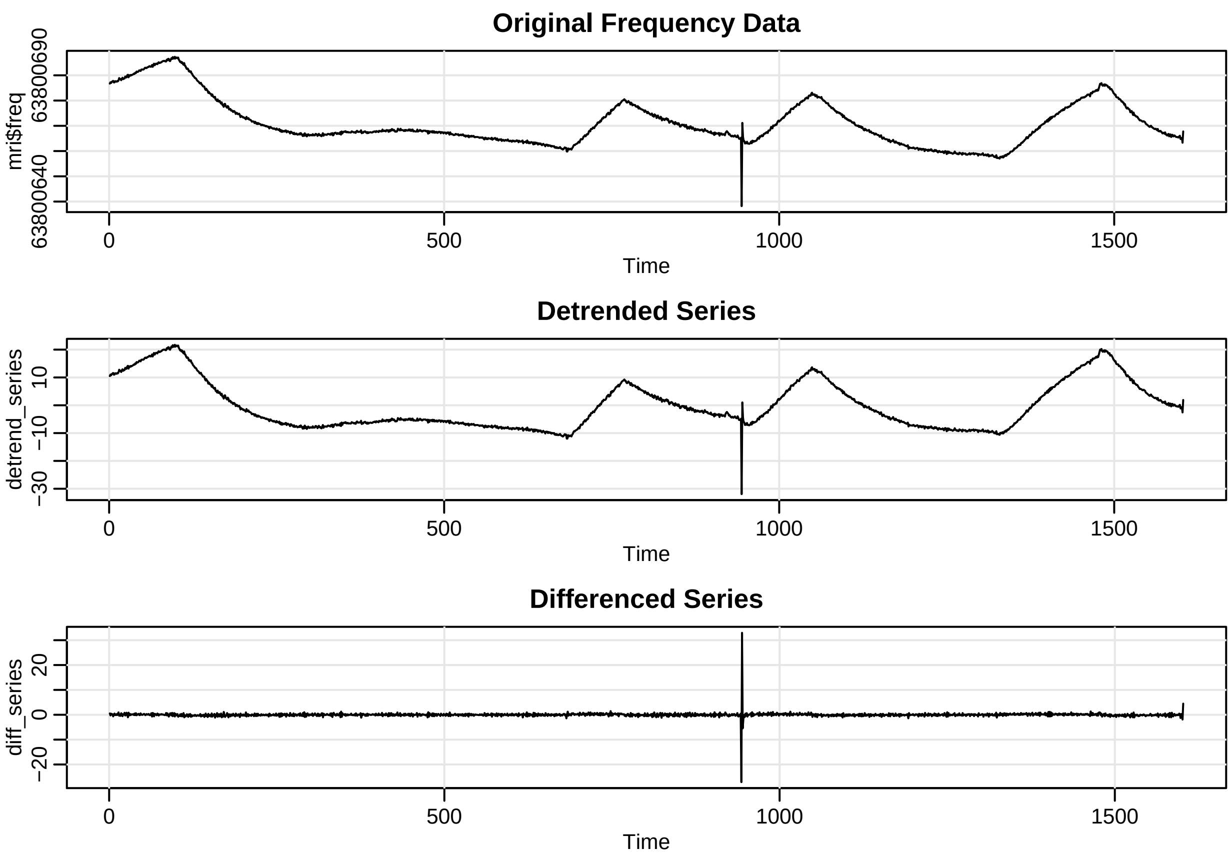


ACF for Internal Pressure variable is interesting - reflects the cyclic nature of series.

Primary Series Manipulations

Detrending + First Differences

```
par(mfrow=c(3,1))
# plot 1
astsa::tsplot(mri$freq, main="Original Frequency Data")

# plot 2
detrend_fit <- lm(mri$freq ~ time(mri$freq))
detrend_series <- resid(detrend_fit)
astsa::tsplot(detrend_series, main="Detrended Series")

# plot 3
diff_series <- diff(mri$freq)
astsa::tsplot(diff_series, main="Differenced Series")
```



The strange point in the middle may be influencing the images. It may be important, but lets take it out and try again.

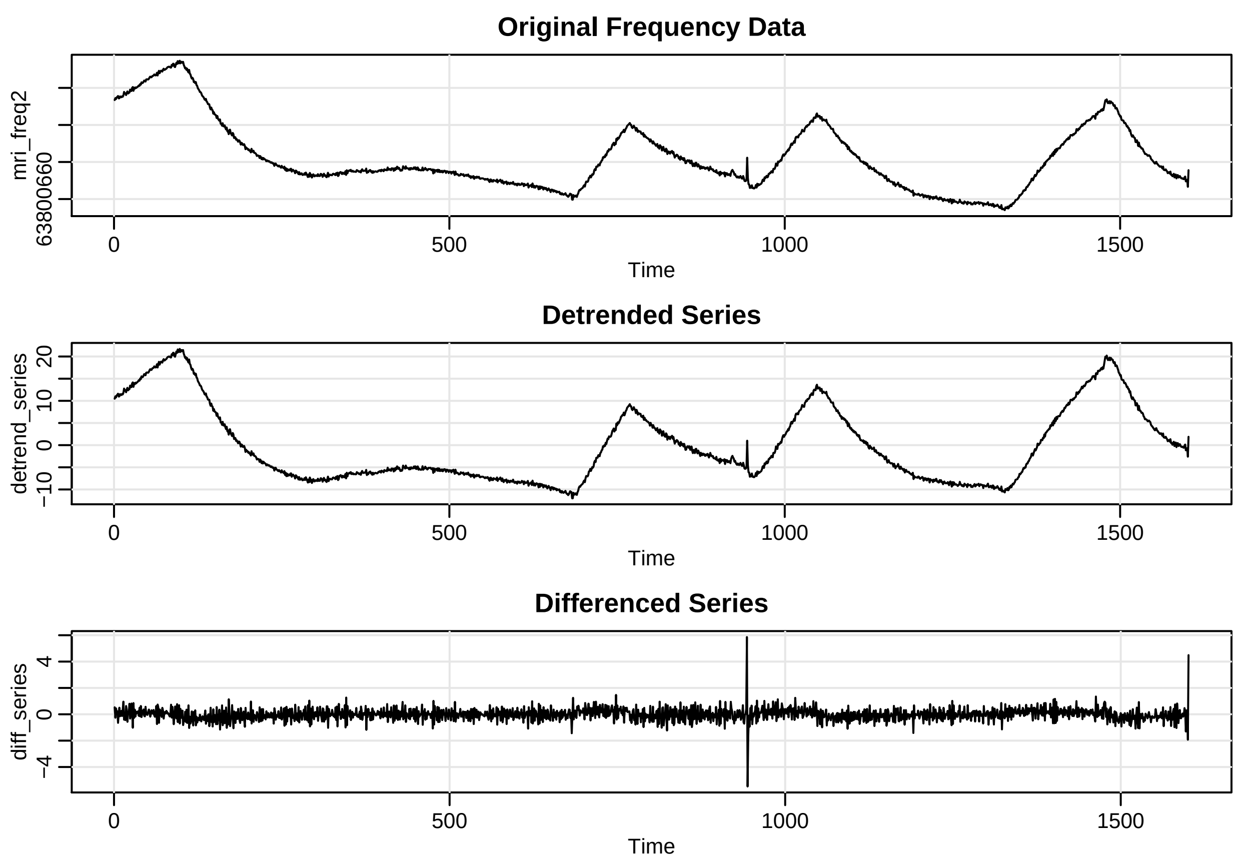
```
print(length(mri$freq))
```

```
## [1] 1603
```

```r
# take away minimum value
mri_freq2 <- mri$freq[-(which.min(mri$freq))]
# make sure that worked
print(length(mri_freq2))
```

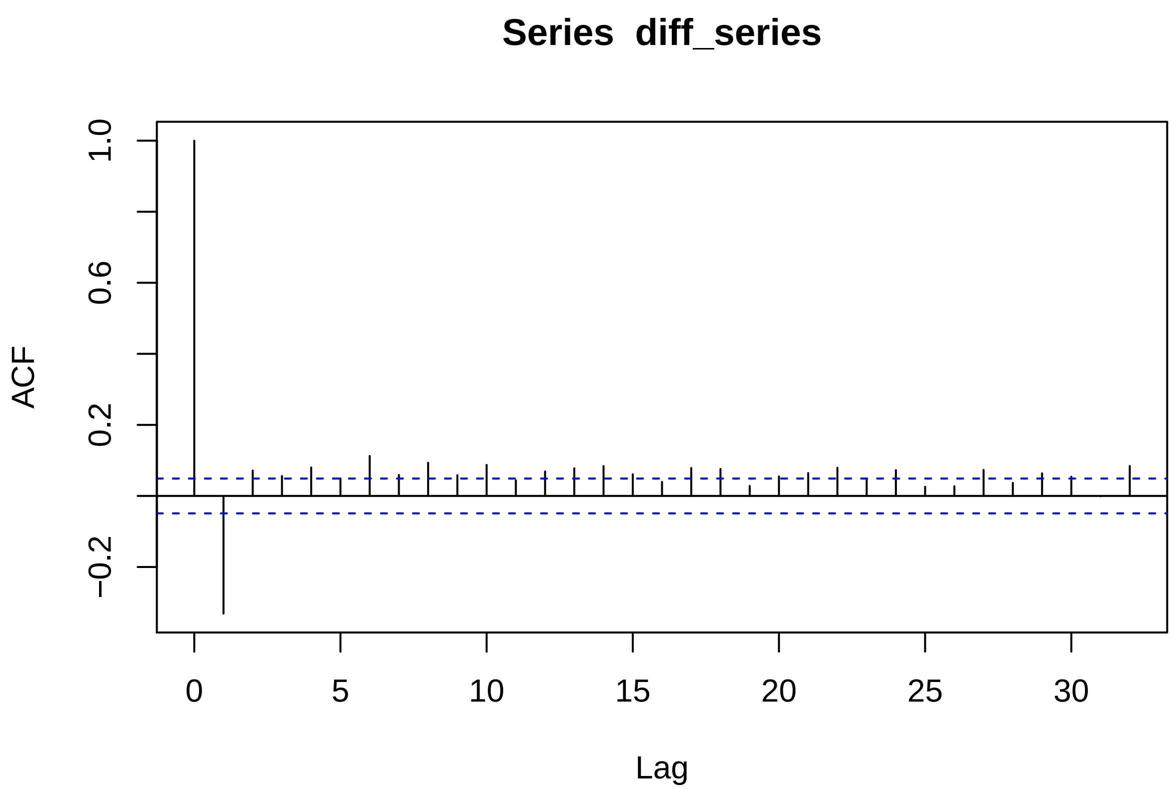
```
## [1] 1602
```

```r
par(mfrow=c(3,1))
# plot 1
astsa::tsplot(mri_freq2, main="Original Frequency Data")

# plot 2
detrend_fit <- lm(mri_freq2 ~ time(mri_freq2))
detrend_series <- resid(detrend_fit)
astsa::tsplot(detrend_series, main="Detrended Series")

# plot 3
diff_series <- diff(mri_freq2)
astsa::tsplot(diff_series, main="Differenced Series")
```



That's somewhat better. Detrending did nothing but change the axis. Differencing looks stationary?

```r
acf(diff_series)
```



Hard to see, but the ACF at a lot of these lag values is significant. We are, however, much closer to stationarity than we were.

Formal Stationarity Check

```
Box.test(mri$freq, type="Ljung-Box")
```

```
##
##  Box-Ljung test
##
## data:  mri$freq
## X-squared = 1576.8, df = 1, p-value < 2.2e-16
```

```
Box.test(detrend_series, type="Ljung-Box")
```

```
##
##  Box-Ljung test
##
## data:  detrend_series
## X-squared = 1598.1, df = 1, p-value < 2.2e-16
```

```
Box.test(diff_series, type="Ljung-Box")
```

```
##
##  Box-Ljung test
##
## data:  diff_series
## X-squared = 175.89, df = 1, p-value < 2.2e-16
```

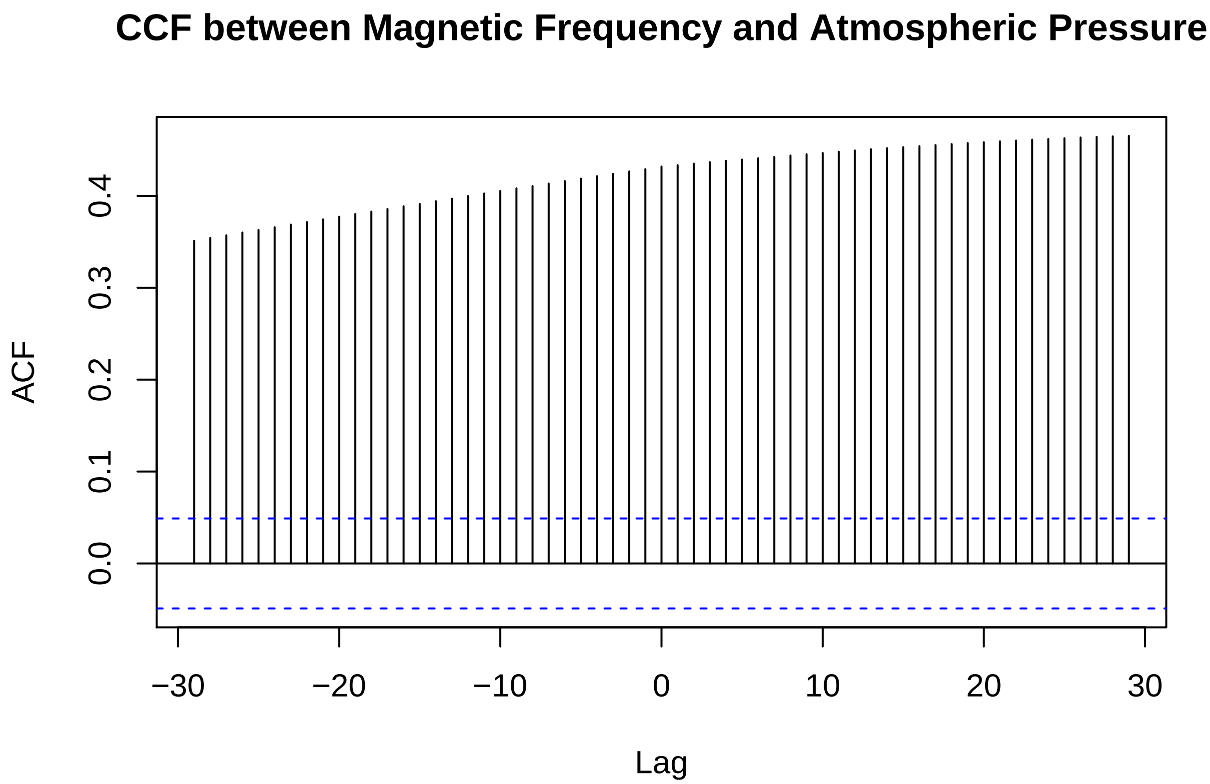
My understanding of this procedure is that we are looking for a high p-value. We are consistently rejecting the null that the data are independently distributed (https://en.wikipedia.org/wiki/Ljung\T1\textendashBox_test).

```
x <- rnorm(500, 0 ,1 )
Box.test(x, type="Ljung-Box")
```

```
##
##  Box-Ljung test
##
## data:  x
## X-squared = 0.0062514, df = 1, p-value = 0.937
```

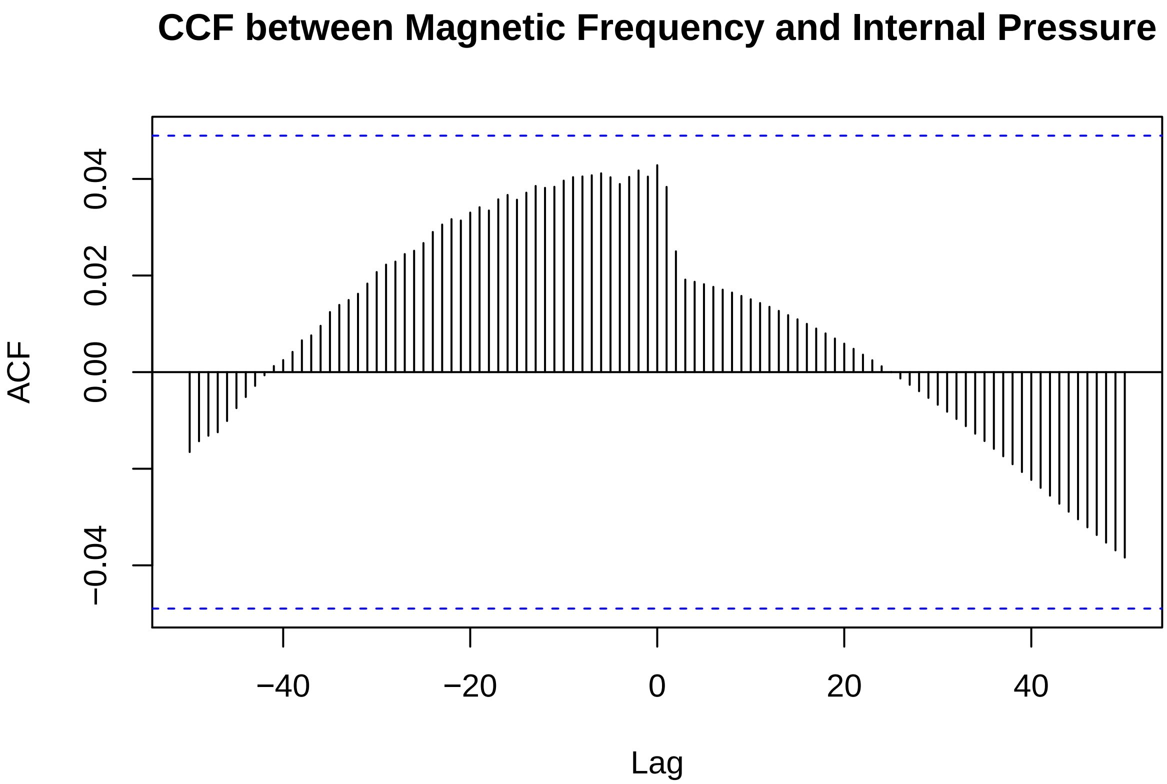
Cross-Correlation Functions

```
ccf(mri$freq, mri$atm_pressure
    , main="CCF between Magnetic Frequency and Atmospheric Pressure"
      )
```



Yikes.

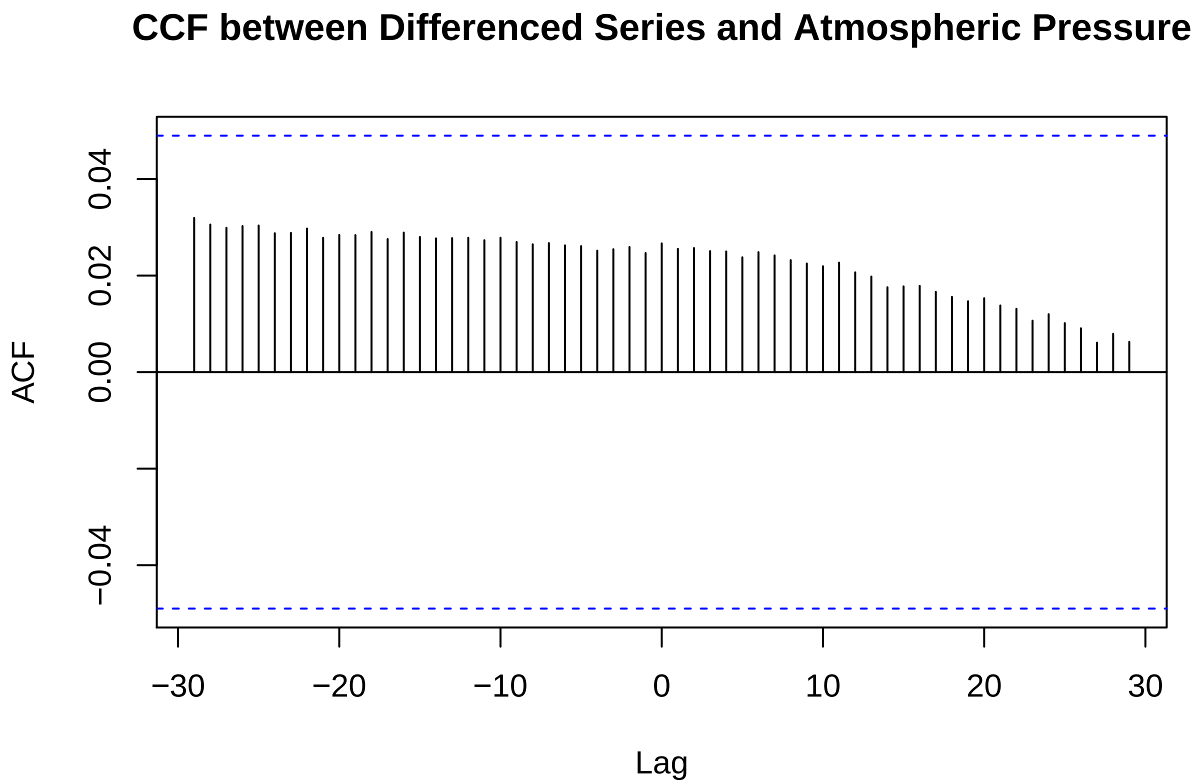
```
ccf(mri$freq, mri$int_pressure, lag.max=50
    , main="CCF between Magnetic Frequency and Internal Pressure"
    )
```



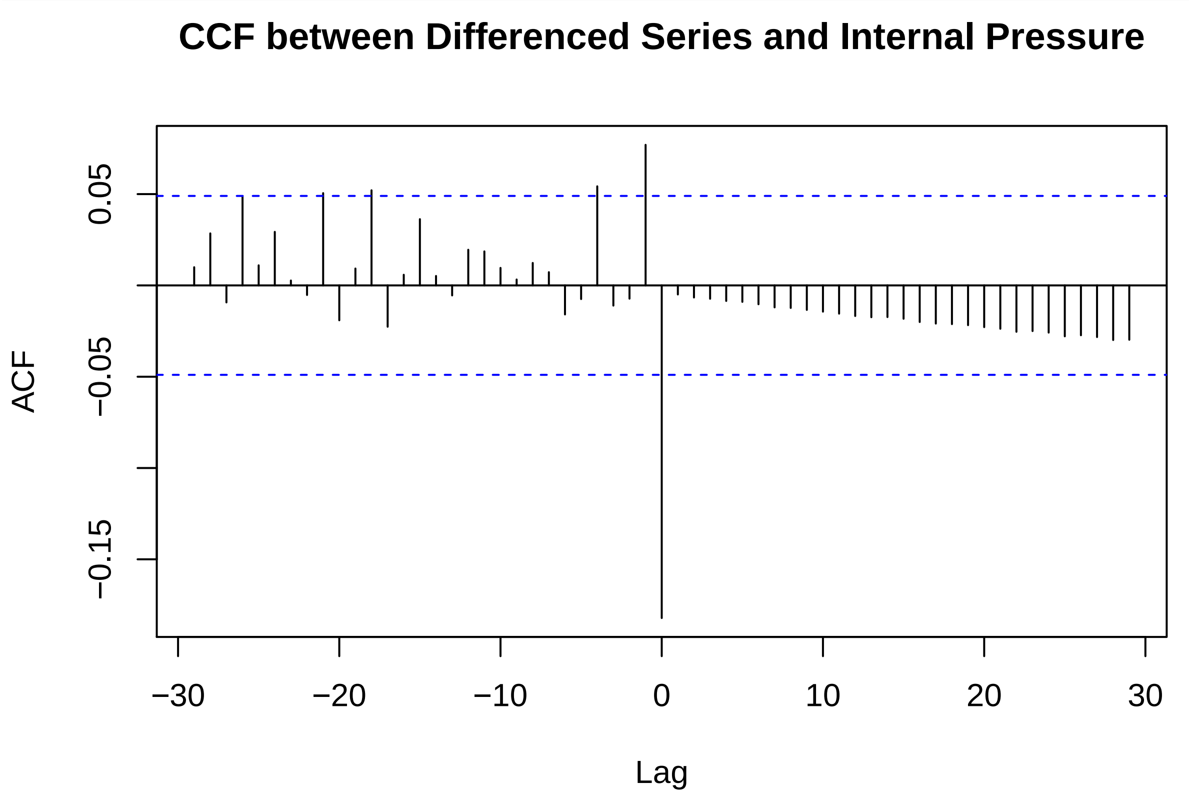
Also yikes, but less so.

Let's swap out the main series for the differenced one.

```
ccf(diff_series, mri$atm_pressure
    , main="CCF between Differenced Series and Atmospheric Pressure"
    )
```




```r
ccf(diff_series, mri$int_pressure
    , main="CCF between Differenced Series and Internal Pressure"
    )
```



This looks promising.